Dynamics of Josephson Vortices in Layered Superconductors

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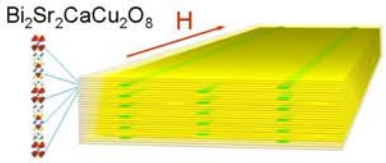
Motivation

- Intrinsic Josephson effect in layered high-T_c superconductors
  → Josephson vortices for $H \parallel ab$
- Low dissipation of Josephson vortices
  → can move at very high velocities
  → source of powerful electromagnetic wave
- Potential for high-frequency applications
- Rich dynamic behavior

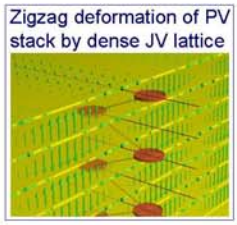


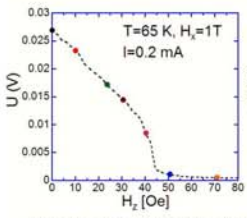
Recent Achievements

Controlling dynamics of Josephson-vortex lattice using pancake vortices

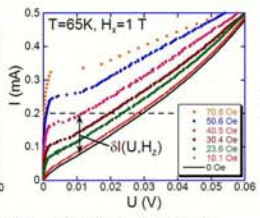
- PV stacks are the most efficient pinners for Josephson vortices (JVs)
- Oscillations of pancake vortices (PVs) due to motion of JVs
  → large contribution to JV dissipation

Stack of Josephson junctions prepared from BSCCO whisker using FIB (Yu. Latyshev)

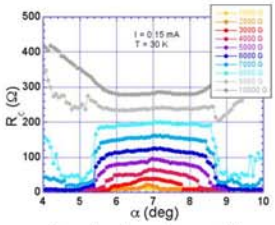




Dependence of Josephson flux flow on c-axis field



IVs at marked points



Angular dependence of the c-axis resistance

Nonmonotonic excess current δI(U):
- Probes relaxation frequency of PVs.
- Leads to jumps in IVs and angular dependencies of voltage measured at fixed current.

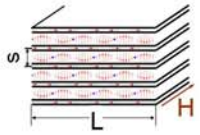
Critical Current oscillations in finite-size stacks

Single small junction, $L < \lambda_J$:
Fraunhofer dependence

$$J_c(\Phi) = J_J \frac{|\sin(\pi\Phi/\Phi_0)|}{\pi\Phi/\Phi_0}$$

Stack of Josephson junctions

Dense JV lattice: $B > B_{cr} = \Phi_0/2\pi s\lambda_J$

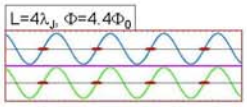


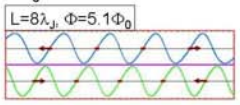
Size-dependent competition:

Interaction with boundaries ↔ Shear interaction between planar JV arrays

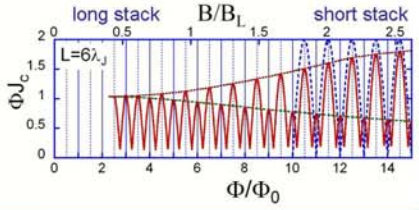
Short stack:
- Φ_0-oscillations
  "almost Fraunhofer"
- rectangular lattice
  (except near $\Phi = j\Phi_0$)

Long stack:
- triangular lattice
- alternating surface deformation
  - decay length $L_B = \lambda_J B/B_{cr}$
- J_c = edge currents
- $\Phi_0/2$-oscillations





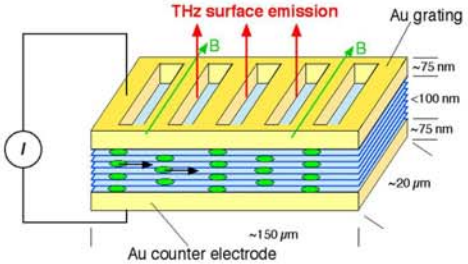
Crossover between the stack regimes with increasing magnetic field at $B \sim B_L = B_{cr}L/\lambda_J$



Experiment (flux-flow oscillations): Kakeya *et al.*, cond-mat/0503498

Future directions

Extraction of THz-radiation from BSCCO mesas:



- 2nd order grating
- matching of wavelength of Josephson plasma wave and free-space radiation
- emission from large top surface

Open Problems:

- Steady states and their stability in small-size stacks
  - regions of rectangular lattice
- Synchronization by external em wave
- Influence of fluctuating pancake stacks on dynamics of Josephson vortices

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